Transforming Construction Delivery through Real Time Wireless Journey Monitoring Technology

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ABSTRACT

Construction delivery of roading projects often requires a delicate balance between the work programme/methodology and disruption to existing road users. As stakeholder considerations become an increasingly important component of the work; the way in which we can minimise, mitigate and manage impacts has been transformed through the use of real-time high quality wireless based Journey Monitoring systems.

These wireless Journey Monitoring systems utilise the detection of customers' Bluetooth and Wi-Fi devices to build up historical and live data on travel times, reliability and route choice. The technology can be powerfully used to support network operational performance in road work environments. On the SH20A to Auckland Airport project, wireless Journey Monitoring was used to validate modelling predictions carried out prior to construction, provide real time journey information for motorists and quantitative project KPI measurements. On another State Highway project in Tauranga a Journey Monitoring system has been installed during the Specimen Design phase, well in advance of awarding a Contractor for the works. The system has been recognised by the NZ Transport Agency as offering value to understand how a complex and sensitive road network area will be managed and improved.

Beca have also deployed high quality Journey Monitoring systems in other areas in New Zealand to provide real time monitoring of traffic management and incident detection together with providing real-time information direct to customers. The combination of innovation and technology is beginning to change the way that motorists can plan their journeys through work sites and give projects a toolbox to actively support operational impacts.

INTRODUCTION

The impacts to a road network by adjacent construction delivery of capital works is often a delicate balance between the intensity and speed of the work against the level of disruption generated to road users. With a positive shift in recent years for greater stakeholder considerations this has placed more emphasis on the way we work and how this disrupts customers' journeys and also how road users can play an active part to minimise disruptions to their journey. With the latest technology, there is an opportunity to connect this to support transformational change to the philosophy of planning and actualisation of temporary traffic management.

Temporary traffic management has historically focused on the application of temporary traffic set up and arrangements on site as dictated by the construction activity. Whilst this in many cases addresses the work requirements, it often fails to satisfactorily acknowledge the considerations for the traffic impacts, how this affects customers' journeys and wider network implications which are becoming increasingly important to the road controlling authorities.

The opportunity to transform construction delivery with one of the latest technologies is in the use of wireless Journey Monitoring systems that utilise high quality Bluetooth and Wi-Fi sensor equipment to provide real time information for measures such as journey times. The real time data gives affected road users information that can support their route planning and also provides contractors and road controlling authorities the ability to draw relationships between traffic impacts and construction activity for betterment purposes.

There are many examples of projects across NZ and in Australia that have connected the dots between the use of wireless Journey Monitoring technology and temporary traffic management to support construction delivery. Many of these have delivered a multitude of positive changes to the way in which contractors plan and implement their work activity and also in allowing road users to interact with real time information to support their journeys through affected areas.

EVOLVING TRAFFIC MANAGEMENT PHILOSOPHY

The Code of Practice for Temporary Traffic Management (CoPTTM) has long driven how temporary traffic management is conducted in New Zealand and sets out a comprehensive foundation for the closure layouts and implementation procedures. In many cases, the construction activity required and Contractor conducting the works would drive the need for the temporary traffic management layouts. Ultimately, the work area and traffic management is captured by an approved Traffic Management Plan (TMP) and managed by qualified Site Traffic Management Supervisors (STMS).

Whilst this has traditionally been suffice to support construction activities, the industry tells us that there needs to be a shift in philosophy that requires greater emphasis for the consideration of traffic impacts to road users and the operational performance of the wider road network. This is driven by many Road Controlling Authorities and evolving industry themes who are also acknowledging the need to appropriately consider their key stakeholders and not just the construction requirements driving the lane and road closures. The NZ Transport Agency as an example has 'putting customers at the heart of their business' as their top priority. And the Wellington City Council has as one of their key objectives the 'efficient utilisation of the transport corridor for the work and the travelling public'

Furthermore, there has been an exponential drive to prioritise safety considerations in the past decade with the likes of the *Safe Systems Approach* launched by the NZ Transport Agency. Safety is related to both the design and operation of roads which includes temporary traffic managed areas where construction activity is in place. A component of this can be linked to the operational performance impacts such as temporary speeds and delays to road users as they inherently affect the road users' interactions with each other and the road environment.

Practically speaking, many road controlling authorities are requiring a greater amount of groundwork up front to prove that the planning of the temporary traffic management sufficiently mitigates, minimise or manage traffic impacts. If done well, this process could also reveal opportunities to conduct work more intensely, if feasible which can result in more efficiencies.

The shift in philosophy for temporary traffic management moves towards greater active planning and management of traffic impacts and examples of Bluetooth and Wi-Fi monitoring equipment to support this shift have proven beneficial with positive results

BLUETOOTH & WI-FI TECHNOLOGY

A high quality Bluetooth and Wi-Fi Journey Monitoring system[1] has been utilised by the New Zealand Transport Agency for several years; the Transport Agency has extensive permanent systems already established in the Waikato, Bay of Plenty, Kapiti, Auckland, Northland, the Manawatu and Wellington. The chosen system has proven to be robust and suitable for New Zealand conditions; units contain a day's battery backup and can be powered from lamp posts / traffic signals or solar panels. The high quality Bluetooth and Wi-Fi system's overall availability has been excellent (>99%).

Sensors in the high quality Bluetooth and Wi-Fi monitoring units detect in-vehicle Bluetooth and Wi-Fi devices such as phones, cars, earpieces, sat-navs and tablets. As the devices pass the detectors they record the time and anonymise that device's unique address through an embedded encryption system. This encryption means that the data cannot be tracked back to any individual or device. This data is then transmitted via the mobile phone network to a server for storage and analysis. Compliance with the Privacy Act is essential, a Privacy Compliance Statement has been lodged with the Transport Agency's Privacy Officer.

The monitoring equipment deployed on the State Highways detects both Bluetooth and Wi-Fi devices on passing vehicles achieving a sample rate of 25-30%. On local roads only Bluetooth detection is utilised with a sample rate from around 15%. As the device passes subsequent sensors, the detection process is repeated and the records matched by the server to generate journeys for those devices.

For privacy, analysis and reporting purposes, individual journeys are normally aggregated into appropriate time slots for further analysis. For this deployment individual anonymised speeds are available.

At the 15-30% level of detection, the selected system can provide large, and statistically significant, information about the traffic flows. On a road with an AADT of 20,000 a 15% sample size provides a 99% level of confidence that the sample results are within 3% of the total traffic flow.

BLUETOOTH AND WI-FI INFORMATION CAPABILITIES

The data provided by the high quality Journey Monitoring system couples with a network server and analysis toolkit that allows for the data to be used powerfully to intelligently support temporary traffic management and the delivery of construction activities. A web based portal can be customised to suit extracting data for journey times for as many combinations as desired for routes connected by various Bluetooth and Wi-Fi sensor units. Data can be manipulated and aggregated for different time periods for comparative purposes easily to provide required information swiftly.

In both the Wellington and Tauranga regions, live Journey Monitoring system data can be fed back to the control centre for display on variable message signs VMSs positioned at strategic locations to allow drivers to make decisions for route choice as shown in Figure 1.

[1] The system that the Transport Agency extensively utilises is the BlipTrack system provided and managed by Beca Ltd.

Figure 1 NZ Examples of Live Travel Time on VMSs in the Wellington and Tauranga Regions respectively from left to right.

In Adelaide, the State road controlling authority have made use of similar technology across their network to monitor and track journey times which have in recent months begun being shared publically via variable message signs that communicate different route options and their corresponding travel times.

Figure 2 Travel Time Signs Example from Adelaide, Australia shown on Channel Ten News - July 23rd 2015

In another Australian State, it is understood that the state road controlling authority have also been investigating different Bluetooth and Wi-Fi monitoring systems for use on construction projects to measure network performance whilst temporary traffic management is in place but to also use this information to support road users by providing live journey time information.

Evidently, there is a growing use of wireless Journey Time monitoring systems and the convenient and easy to access information that they collect. This is then used in a multitude of ways of which one example is displaying travel times to support road user route choice.

CASE STUDIES

The following case studies look at four different examples of how high quality wireless Journey Monitoring systems have complemented temporary traffic management for construction activity. All of these are New Zealand based examples and each represent differing circumstances as described below:

1. SH20A to Airport Upgrade - Auckland: Currently under construction with a wireless Journey Monitoring system established leading up to construction activity beginning. This system is used to provide real time journey information to the public and recorded data is also used for internal key performance indicators.
2. Bayfair to Baypark SH2 upgrade – Tauranga: Currently under Specimen Design phase and early identification of challenges with construction staging and network disruption has resulted in the establishment of a wireless Journey Monitoring network which is currently gathering background data which will be useable by the awarded Contractor.
3. State Highway 1 (SH1) weekend southbound closure – Huntly: Bridge works closed SH1 southbound north of Huntly. The excessive delays made the newspaper and coincidentally, there were wireless Journey Monitoring units already setup in the area which allowed for an estimate of the true delay time.
4. State Highway 3 (SH3) Rock Bolting Programme – Manawatu Gorge: Stop/Go operation required to manage safety of vehicles during rock bolting works near a cliff face.

1. SH20A to Airport Upgrade - Auckland

The SH20A to Airport upgrade includes the construction of a new grade separated interchange for the existing at grade Kirkbride Road intersection. As the key corridor connecting between the Auckland International Airport and Auckland CBD, the sensitivities of any disruption to journeys were therefore amplified for this project. The Alliance delivering this project acknowledged that a shift in approach and philosophy was required and the opportunity to marry this with Bluetooth and Wi-Fi technology is well demonstrated in its use for transforming construction delivery.

A total of ten Bluetooth and Wi-Fi sensor units have been installed around the Project Area to provide live and strategic data of traffic flows, speeds and any changes along key routes in the area. A key benefit of the selected system is the ability to display real-time travel information in various formats.

a. Screen Based Display: A PC based project display screen has been created (shown in Figure 3) that provides the current travel times around the Project Area with colour coded times to denote delays longer than 3 minutes and above that of the baseline travel time for that time of day.

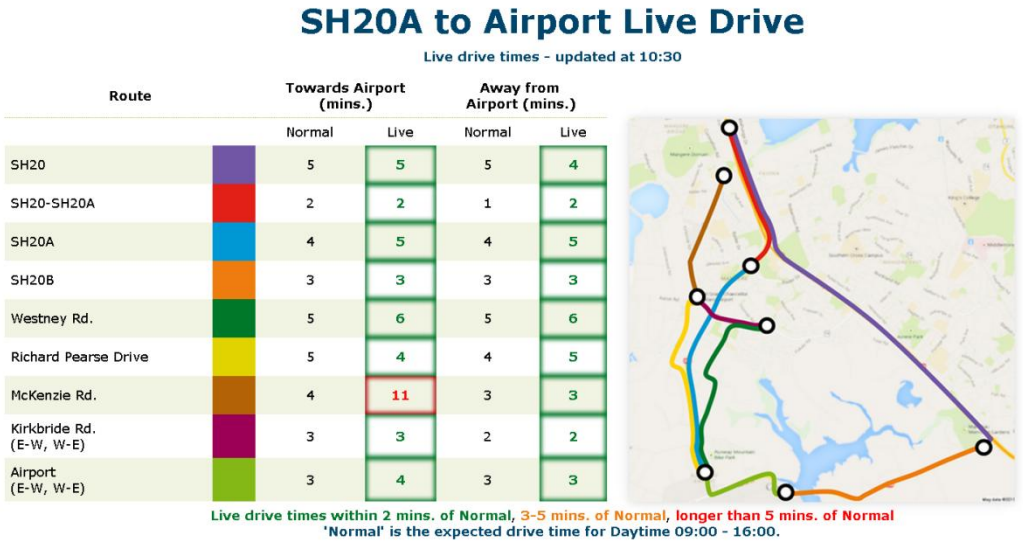

Figure 3 PC based travel time display

a. Smartphone Based Display: A mobile friendly real time journey service DriveLive-AKL is available at http://www.drivelive.nz/AKL (Figure 4). Figure 5 also provides the logic structure of the web page with the user able to pick an origin and see live journey times by at least two routes to and from a set of Destinations. Consideration was given to provide only a limited number of route options and to discourage the use for the system whilst driving. A passenger or a driver setting out could make use of this information- as could someone stuck in stationary traffic.

Figure 4 DriveLive Auckland Site

http://www.drivelive.nz/akl

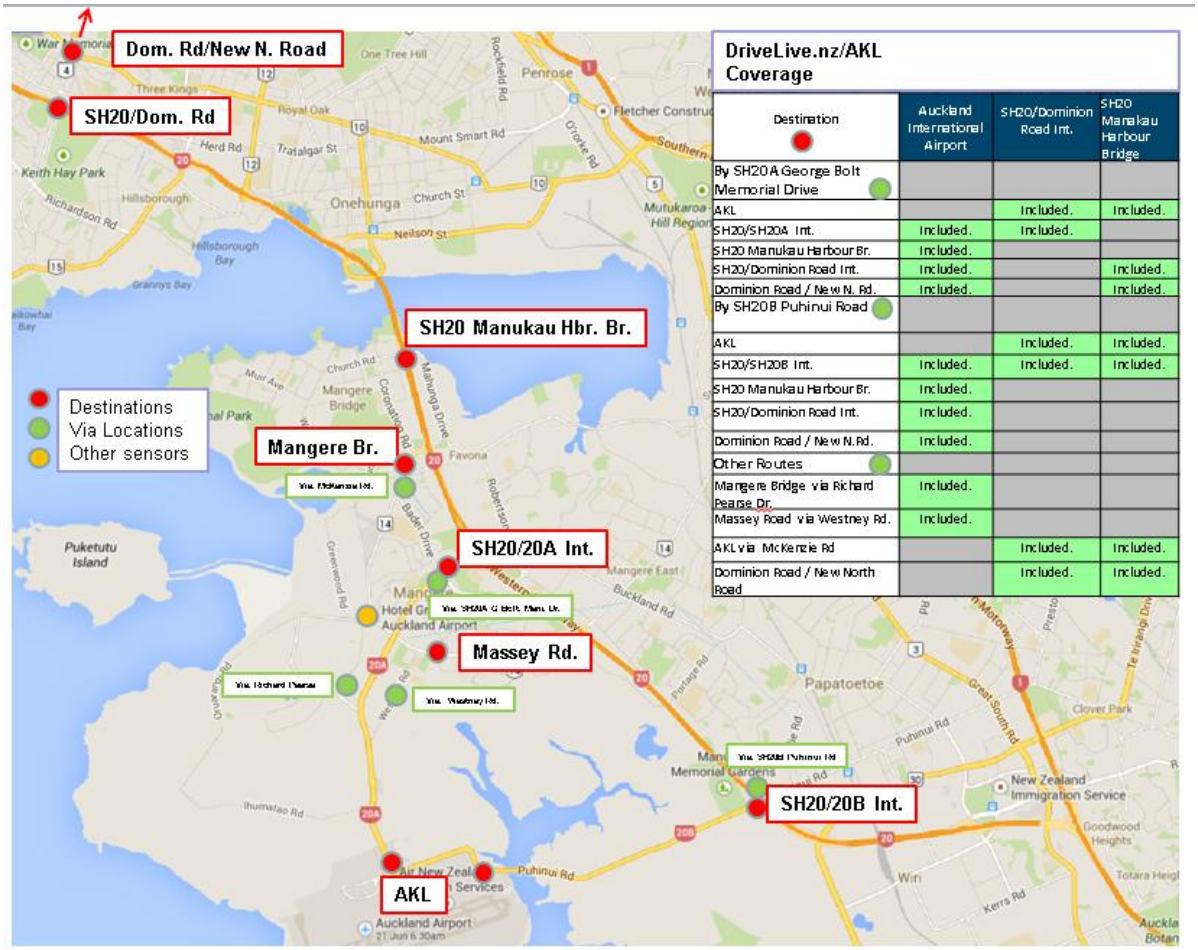

Figure 5 Specification of DriveLive - AKL

The high quality Journey Monitoring system used has an open access module, it can also export live data via an API (XML) or SOAP based protocols. This allows for live data to be fed to the Auckland Traffic Operations Centre (ATOC Smales) allowing for the possibility to display live travel time data to VMS signs. This methodology is already in use with the Wellington Traffic Operations Centre to provide real time travel information to VMS boards.

During the establishment phase for the construction activity, traffic models were used to forecast the likely impacts for the proposed construction staging. With the availability of some preliminary journey time data collected, the SH20A to Airport project was able to use the Bluetooth data to validate these models. This was able to increase the level of accuracy of the base traffic model which subsequently provided more reliable predictions of the staging impacts.

With construction activity in full swing, the Manukau Harbour Crossing Kirkbride (MHXK) Alliance delivering this project have further used the collected journey time data as one of the project's Key Performance Indicators. This has given weight to the actual performance of the surrounding network by connecting it with their success measures. Table 1 below tabulates the categorisation of the difference between the measured journey times for each month compared with the base statistics collected prior to the beginning of construction activity.

Table 1 MHXK Alliance Travel Time Key Results Categorisation

Performance	Breakdown	Step behind	Business As Usual	Step ahead	Breakthrough
Traffic delays	Greater than 5 minutes delay	3-4 minutes	2-3 minutes	0-1 minutes	Improvement in traffic flow

An example of one of the monthly summary charts that informs the travel time key results for the project is shown in Figure 6 below. Key information presented show the number of vehicle journeys captured each week and the average delay compared with the baseline data.

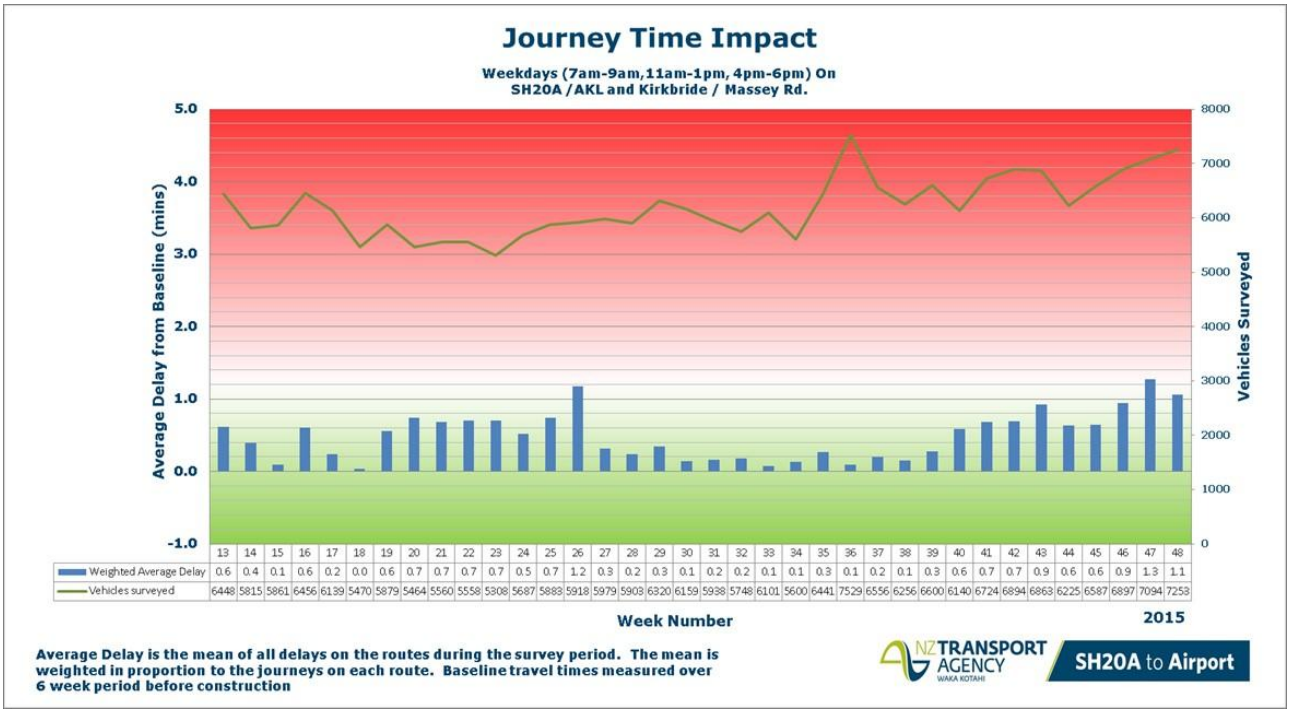

Figure 6 Monthly Journey Time Information Summary

The SH20A to Airport project have demonstrably used the wireless Journey Monitoring technology to change the way it is delivering the temporary traffic management and construction of the project. Specifically, this technology has been used to provide better accuracy in traffic staging planning, support operational performance through live journey time information and is used to inform project performance measures placing greater emphasis on active management to achieve positive operational performance results.

2. Bayfair to Baypark - Tauranga

The Bayfair to Baypark upgrade project includes the widening of SH2 and grade separated interchanges with SH29 and at Girven Road. Whilst the project is only in the Specimen Design phase, it has been acknowledged that construction of this project could potentially generate significant delays as operational conditions are already challenging during peak periods. Early consideration has therefore been given during the Specimen Design phase to understand key routes in the affected area and possible alternative routes during construction as summarised in Figure 7.

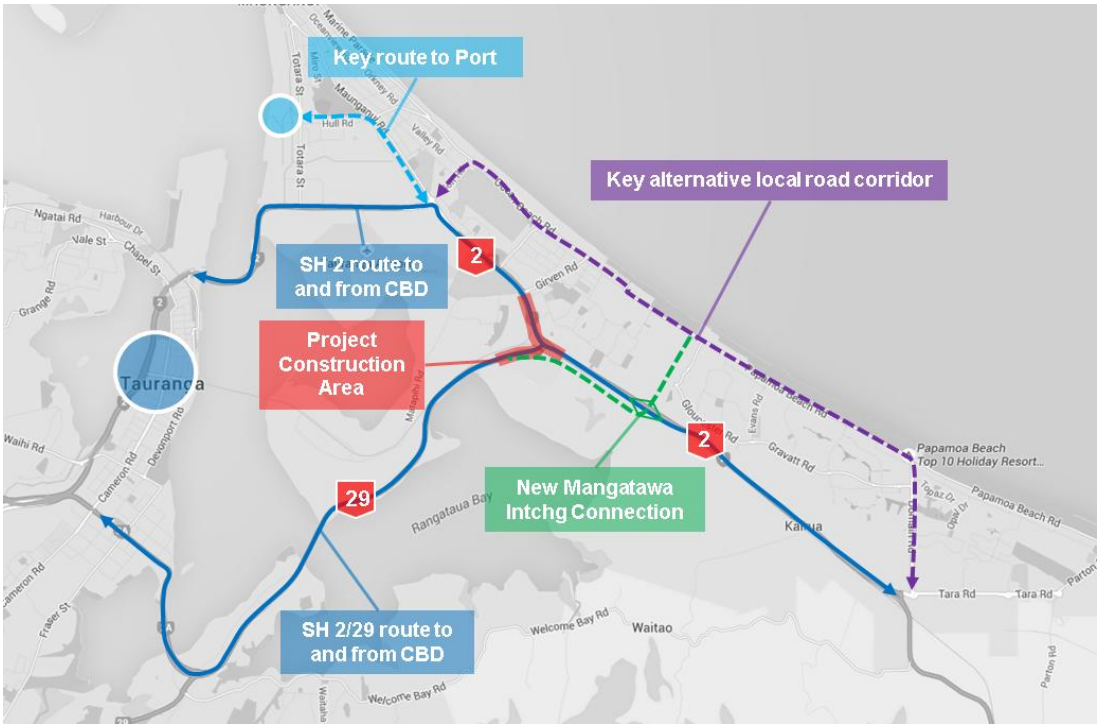

Figure 7 Bayfair to Baypark - Road Network Impacts Consideration Summary

Based on the considerations above, the project proposed to the NZ Transport Agency an opportunity to monitor the existing network (which had recently connected with the newly completed Tauranga Eastern Link) during the Specimen Design so that baseline data could be captured to support the awarded Contractor during construction. With an awareness of existing Bluetooth and Wi-Fi monitoring units, the project team were able to put together a monitoring network proposal for the NZ Transport Agency to consider (as shown in Figure 8).

Figure 8 Proposed Tauranga Bluetooth and Wi-Fi Monitoring Network.

After confirming the monitoring network, additional units were deployed as part of the project to form a complete network across Tauranga that will provide comprehensive data to better inform

the construction staging planning. This is a unique arrangement that has used Bluetooth and Wi-Fi sensor technology well ahead of the construction delivery to further mitigate, minimise operational performance impacts.

3. SH1 Southbound Weekend Closure - Huntly

On Saturday, the 27th of June 2015, an undisclosed contractor was carrying out bridge repair works on SH1 near Huntly which closed the southbound carriageway. Site observations in early-morning through Huntly heading northbound saw queues in the order of 500m to 1km with noticeable delays. The delays continued to increase throughout the day and were sufficiently significant to attract a news article on the Stuff website as shown in Figure 9 below.

Major delays on State Highway 1

stuff.co.nz

STACEY OLIVER
Last updated 15:47, June 27 2015

Southbound motorist travelling along State Highway One near Huntly faced major delays on Saturday.

Bridge repairs closed Huntly's main drag, Great South Rd, and saw southbound traffic diverted along Hakanoa St.

River Haven Cafe employee Denise Neilson said the cafe, which is a popular tourist stop, had not been notified about the roadworks. She only found out about it because someone living on Hakanoa St phoned to ask if there had been an accident as traffic was detoured along the street.

Nielson said one bus driver had been sitting in traffic for an hour and half while another couple, travelling from Waiuku, had been waiting for two hours.

The couple were quite upset about the unexpected delay, she said.

"Northbound traffic is fine, its just the southbound traffic that can't get through. But even in saying that, even they [northbound traffic] can't through that bypass. They have to come through Huntly township."

- Stuff

Figure 9 Newspaper Article for Delays Relating to SH1 Huntly Bridge Repair works - www.stuff.co.nz

Coincidentally, the NZ Transport Agency had Bluetooth and Wi-Fi monitoring units in the vicinity of the works which showed additional journey time were in excess of 70mins during the worst of it as shown in Figure 10.

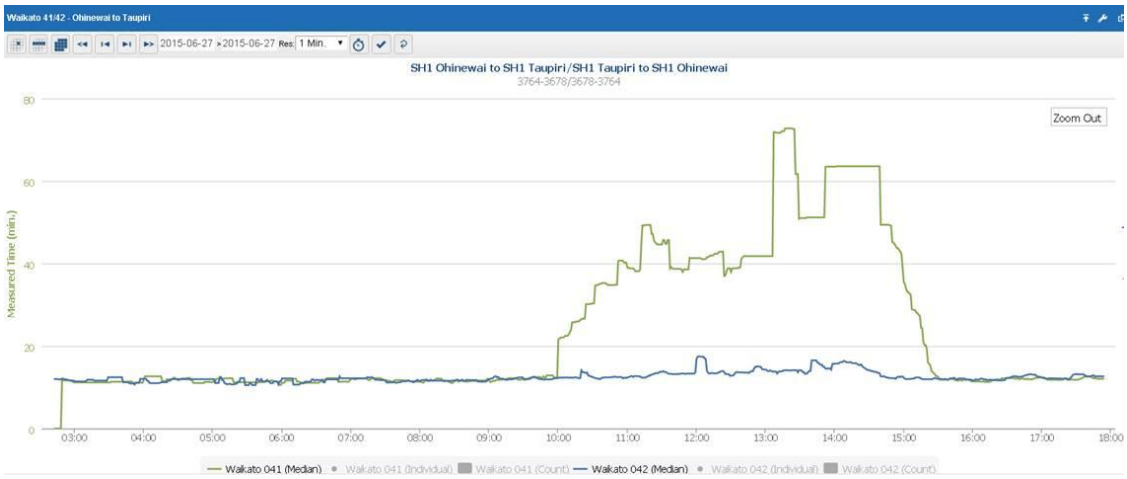

Figure 10 SH1 (Waikato) Journey Time Information from Bluetooth and Wi-Fi Data for Saturday 27th June 2015

4. SH3 Rock Bolting Programme - Manawatu Gorge

The SH3 route through the Manawatu Gorge is a strategic route that is susceptible to rock falls and closures. As part of a rock fall mitigation rock-bolting programme an extended period of Stop/Go working was required. To provide real time information on any delays the contractor and the Transport Agency with a suite of tools.

The site STMS and local supervisors were provided with a mobile phone based service that gave real time information on queuing times, transit times and vehicle flow rates.

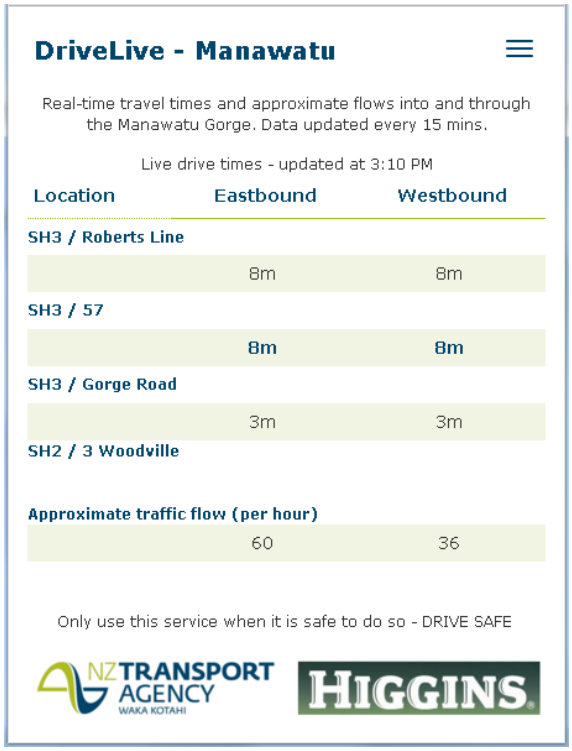

Figure 11 - STMS Mobile 'App' showing queue times, transit times and flow rates

This is an example of the level of customisation allowable to extract relevant and useful information and present it in an easy to access and user friendly format. The wireless Journey Monitoring system was used to review operational arrangements for the Stop/Go tidal flow set up.

CONCLUSIONS

Temporary traffic management to support construction delivery has historically focussed on the requirements of the work activity and setting out what is required in accordance with CoPTTM. Whilst this in many cases satisfies the work requirements, it is falling short of the mark required as the industry points to a requirement to shift the philosophy in which this work is planned and implemented. Road controlling authorities are acknowledging the need to better consider their customers i.e. the road users and how construction activity can minimise the impacts to their journeys. With safety also being a top priority objective for all road controlling authorities, there is an inherent connection between operational performance impacts and how this affects the road users' interactions with each other and the environment.

With the latest technology in wireless Journey Monitoring systems, there has been an ability to support the shift in temporary traffic management philosophy and transform the delivery of construction work activity. Using high quality Bluetooth and Wi-Fi sensors, the increasing ownership of vehicles and mobile phones with this technology can be capitalised on to obtain live

and accurate information about how a road network is performing. This technology is coupled with well-developed web based processing systems that are fully customisable to the information produced and the parameters that define this e.g. time and location. How this information is then used is almost limitless but a few examples include reporting live journey time information on VMS signs on the road network, through websites or web based apps for mobile phones. Depending on the recipient of this information, this further diversifies how the data can be used. For example, a road user could use the information to inform their travel time or route choice whereas the contractor implementing the temporary road works can identify specific locations that may be generating greatest delay and review measures to minimise the impacts caused.

There are a growing number of examples in which wireless Journey Monitoring systems has been applied to the project and at various phases also for different purposes. The way in which the data is used also varies significantly which further validates the customisation ability for the information coming through for this technology. These examples extend off shore with some locations in Australia also. In other cases, an example of coincidental availability of nearby high quality detection units was able to confirm the unacceptable delays it generated and in hindsight could have avoided.

With a multitude of possibilities for information collected from the Journey Monitoring systems and how this is used, the continued evolvement of this technology will only offer greater capabilities in how construction delivery can be more actively planned for and delivered smartly to acknowledge road users and wider network impacts.